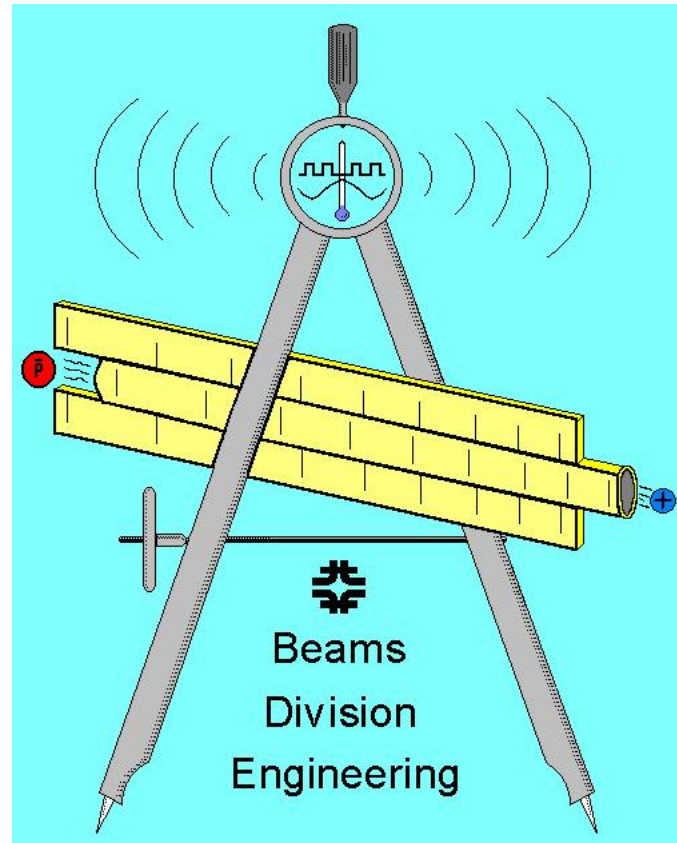


Accelerator Complex Reliability



Outline

- You will hear
 - Status of projects since October DOE Review.
 - New issues since then.
 - How we do our maintenance and planning.
 - Examples of tracking system performance.

- I believe you will find we have a well established system and place a high emphasis on reliability and performance.

Information From the DOE Review

- As of 10/01/02 the largest accumulated downtime was from:
- Tevatron Accelerator Systems- TQUEN
 - Magnet Quenches (all causes)
 - WARNING be careful of what the name implies! Some failures in this category were caused by the protection systems i.e. QPM or VFC that caused the magnets to quench.

Kicker Pre-fires

- Case of "...if a little is good, a lot is better!"
 - Reservoir pressures were raised to make kicker firing easier on the tubes. It also made kicker firing Easier! Put the tube very near the threshold of pre-firing so anything could (and did) set them off.
- We backed down in March and have not had a pre-fire since then. It is still too soon to tell what the longer term will bring.

A Case Study

- Last year VFC's were the cause of 10 lost stores.
 - 7 failures were in Low Beta houses where there are 45 cards installed.
 - 3 failures were in the rest of the machine where there are 204 cards installed.

Investigation

- The VFC cards were built when the Tevatron was built ~ 1983
- Past problems pointed to high humidity as being a culprit. (50 Meg resistors)
- All of these failures happened in warm weather BUT the humidity in the buildings was low(?).

VFC Status

- As of May 1st 2003 **ALL** VFC cards have been replaced. Additionally, design changes were made to the card cages to minimize the number of connectors thus removing another failure prone device. The EE Support Department also changed the values of the voltage divider resistors to make them less humidity and dust sensitive.

Cryogenic Wet Engines

- The cryogenics Wet Engines were overhauled during one day M&D periods and were completed during the January shutdown.
- A combination of accelerator maintenance history, and a life test, showed a MTBF of 13,000 hours for the wet engines. All should be fine until the next shutdown.

How about the bigger picture?

- Given the age of many of the systems at the laboratory, obsolescence is a serious problem. We keep as many spares as possible for the systems we have and prioritize the systems that can be replaced given limited resources.

FY03 Upgrade/Rehab Items

STATUS

- 1)VFC's - Done
- 2) Wet engines - Done
- 3) Cold Compressor Bearings – No longer a dilemma!
- 4) Compressor Starters – On schedule 1/3 in FY02, 1/3 in '03, 1/3 left. *Might have to defer FY'03 due to budget problems!*
- 5) Failure of PEI water cooled transformers – Critical supplies done, will have to spend more on this.
- 6) Failure of Kicker Ceramic Beam Tube – We have found 2 new vendors and are procuring samples. No longer a problem since we have successfully recovered tubes from old kickers.
- 7) Controls Equipment – Staged replacement, Review and plan soon.

And the Future

- A Vulnerability Study was commissioned to find what items would keep us off for a Three month time period if they failed.
- This study generated a number of items that will require replacement based on the lack of available replacement parts. Industry no longer supports some of these.

Dec 2002 White Paper & Plan to DOE

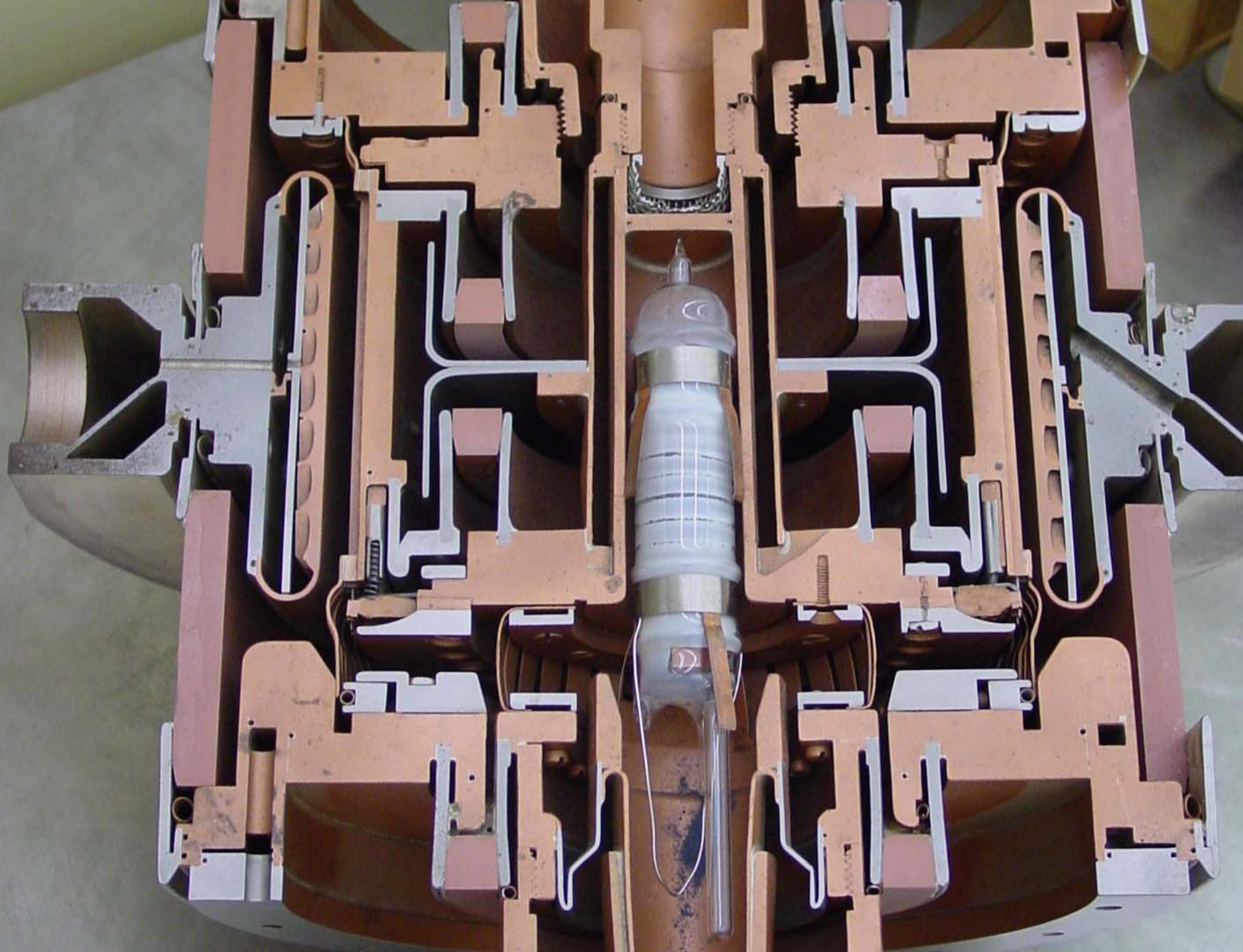
Area		Component Cost Updated M& S Cost M&S Cont Status or Plan			
Linac	7835 Amplifier Tubes	\$1.5M	\$1.6M	60%	FY03-6
Linac	F1123 Switch Tubes	\$200K	-		completed FY03
Linac	New Quadrupole Power Supplies		\$1.0M		-maintain existing supplies
Linac	Water System Rebuild	\$500K	-		completed FY03
Booster	Orbit Bump Magnets	\$1M	\$150K	40%	FY04 + labor in WBS –
Table 3.					
Booster	Low Level RF	\$100K	\$100K	40%	FY05
Booster	High Power RF	\$7.5M	-		Defer
Booster	RF Accelerating Cavities	\$10M	-		Defer
Main Injector & Beamlines					
	Dipole PS Transformers	\$150K	\$150K	40%	FY04
	Quad PS Transformers	\$80K	\$80K	40%	FY04
Main Injector	Kicker Vacuum Tubes	\$500K	\$50K	40%	FY04 – found spares &
vendor					

From Plan Submitted to DOE

Tevatron Low Beta PS Magnetics		\$30K	\$30K	40%	FY04
Tevatron Cryogenics	Centrifugal Cold Compressors	\$100K	\$100K	40%	FY04
Site Infrastructure	345-KV Switchgear KRS	\$200K	\$200K	20%	FY06
Site Infrastructure	345-KV Switchgear MSS	\$300K	\$300K	20%	FY06
Site Infrastructure	345-KV MSS Transformer	\$1.2M	-		Defer
Site Infrastructure	Filter Damping Resistors	\$20K	\$20K	20%	FY04
Other Major Maintenance Items					
Tevatron	Replace Tevatron Magnet Stands	\$324K		40%	FY03-5
Tevatron	Correct Tevatron dipole coil sag	Labor only			FY03-4

The Most Recent Crisis

- This has a wider impact than just Fermilab



Current Crisis for Four Labs

- The Burle 7835V2 is used by Argonne, Brookhaven, Fermilab, and Los Alamos
 - (and US Navy - 2 sockets)
- Burle has had great difficulty in producing good tubes over the last year.
- We have managed to receive one good tube as a spare. This is after getting tubes from Argonne and Brookhaven

Why the trouble?

- Numerous retirements of key "artisans" at Burle.
- Some pressure from Military side of the house for AWACs tubes.
- Seen as a diminishing market with little return on investment.
- Captive audience! No one else makes these tubes.

What is being done?

- Working closely with the vendor to increase production.
- Working closely with the vendor to understand failures.
- Working with alternate sources for tube rebuild.
- Working with Los Alamos on alternate power system

Schedule

Gentlemen,

Thank you very much for your time last week. As discussed, we are doing everything possible to complete your 7835's as quickly as possible. The current Fermilab delivery schedule, as a result of our May 1st production meeting is as follows:

End May – 7835 New

July – 7835 New

Sept – P2R4

Oct – A30R6

Oct – N16R8

I am awaiting completion of the TC&A for AZ4R1. I believe that this device requires an anode, so it is not a quick turn-around item. I should have that TC&A, this week. I will also advise what Fermi can do to help us accelerate the delivery schedule, per our meeting.

We will contact you regarding the progress of these devices.

Please let me know if you have any questions.

Regards,

Bob Rutherford

Los Alamos Connection

- John Lyles at Los Alamos is working to build a new power station using a different tube (called a Diacrode) developed by Thales.
- New tube is a power tetrode.
- Continental Electric of Texas is interested in commercializing the power station.

Lets Talk Maintenance

- In the beginning (October of 1972 for me!) we ran until the wheels fell off then fixed them.
- Later we built in maintenance periods and often broke the machine in the process.
- Now we follow what is referred to by industry as: Reliability-Centered Maintenance.

- I follow the developments in the reliability area as described by the Reliability Analysis Center - this is a DoD Information Analysis Center Sponsored by the Defense Technical Information Center and Operated by IIT Research Institute.

Overview of the Concept

- "Prior to the development of RCM, it was widely believed that everything had a "right" time for replacement or overhaul. Many maintenance personnel believed that by replacing parts of a product or overhauling the product (or reparable portions thereof), the frequency of failures during operation could be reduced."

Concept cont.

- “Despite this commonly accepted view, the results seemed to tell a different story. In far too many instances, PM seemed to have no beneficial effects. Indeed, in many cases, PM actually made things worse by providing more opportunity for maintenance induced failures.”

What is RCM

- The objective of maintenance is to preserve and item's function(s).
- RCM focuses on the end system. (accelerator for us)
- Reliability is the basis for decisions.
 - Failure characteristics of the item in question must be understood to determine the efficacy of preventive maintenance.

RCM cont.

- RCM is driven first by safety and then economics
 - Safety must always be preserved. When safety is not an issue, PM must be justified on economic grounds.
- RCM acknowledges design limitations.
 - Maintenance cannot improve the inherent reliability - it is dictated by design.

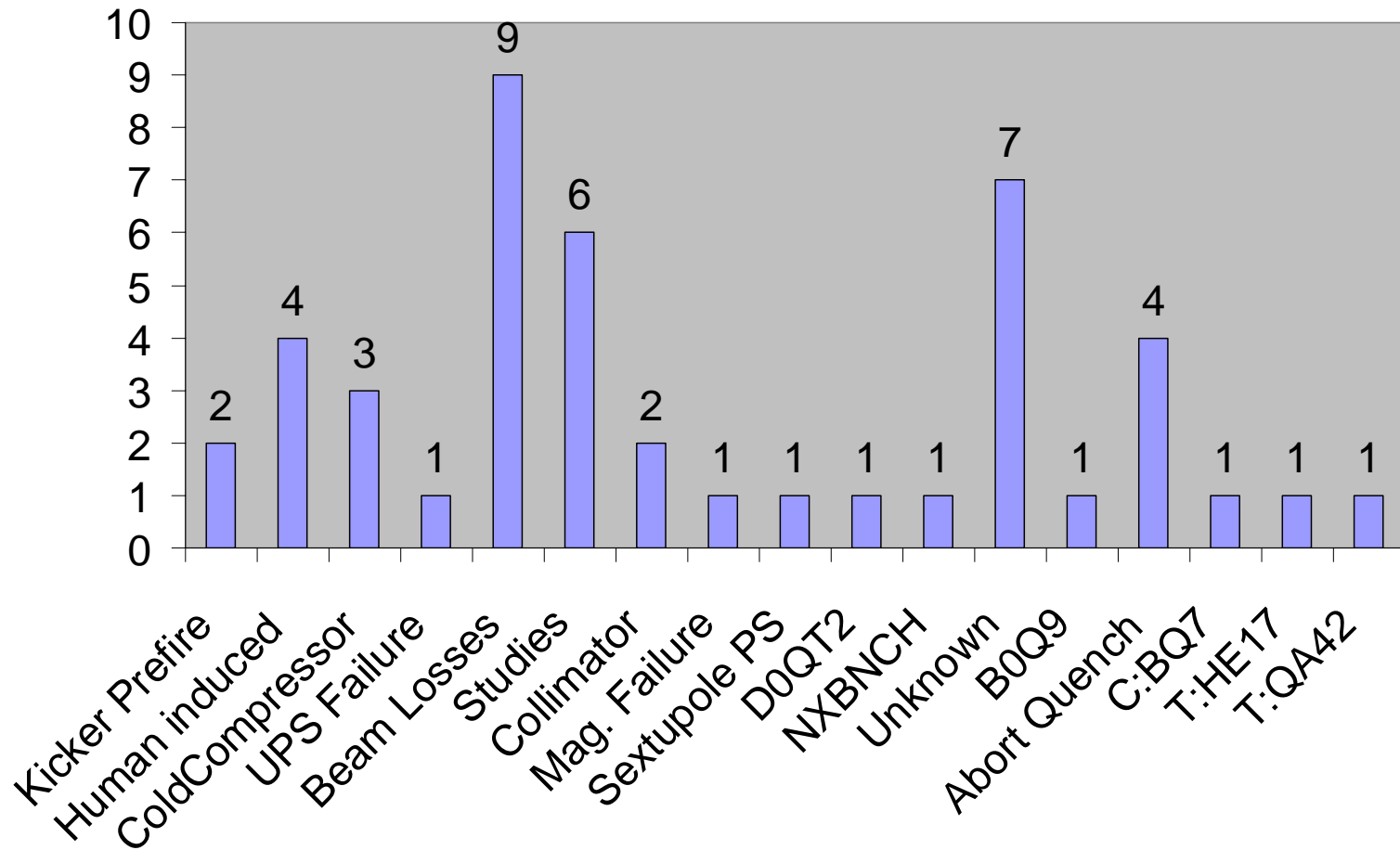
- RCM is a continuing process.
 - Differences between the perceived and actual design life and failure characteristics are addressed through age (or life) exploration.

2/10/2003 20:52	4.07 hrs.	TQUEN	Quench A1 and F4, Kicker prefire	x	Kicker Prefire	2
2/11/2003 14:42	57 min.	TQUEN	Tev quench at A11U due to turning on dampers during shot setup	x	Human induced	4
2/11/2003 20:54	3.97 hrs.	TQUEN	Tev quench A2, due to UPS failure at A2.	x	Cold Compressor	3
2/12/2003 19:48	2.13 hrs.	TQUEN	TeV Quench at B3, 36x0 proton only store, right at acceleration	x	UPS Failure	1
2/13/2003 19:41	3.83 hrs.	TQUEN	Tev Quench at B3, early accelration of store 2115	x	Beam Losses	9
2/16/2003 0:15	2.75 hrs.	TQUEN	Quench @ F3 due to CC turning off - no frig problems found; not beam induced	x	Studies	6
2/20/2003 9:55	2.18 hrs.	TQUEN	Quench, lost store. At DZero LB and C48U & L	x	Collimator	2
2/22/2003 22:00	2.42 hrs.	TQUEN	Tev quench at F36L due to F3 cold compressor trip	x	Mag. Failure	1
2/24/2003 6:21	2.65 hrs.	TQUEN	TeV quench at E15U due to cc trip.	x	Sextupole PS	1
2/26/2003 21:50	1.75 hrs.	TQUEN	Quench A11L upon termination of 36x0 studies store.	x	D0QT2	1
3/1/2003 8:42	7.30 hrs.	TQUEN	Tev quench A1 B1 F4 & Lo betas due to PAK3 pre-fire	x	NXBNCH	1
3/9/2003 19:50	9.95 hrs.	TQUEN	Quench at A15 on 1st 980 ramp & kautzky replacement.	x	Unknown	7
3/15/2003 19:48	1.53 hrs.	TQUEN	Quench at DAU3 and DBU1	x	B0Q9	1
3/16/2003 8:21	1.23 hrs.	TQUEN	TeV quench at F48L due to feeddown sextupoles at C2 and F2 tripping off.	x	Abort Quench	4
3/16/2003 13:48	5.95 hrs.	TQUEN	Quench @ C4, during dry squeeze, due to D0QT2.	x	C:BQ7	1
3/21/2003 22:52	4.63 hrs.	TQUEN	Quench @F4, possible collimator problem	x	T:HE17	1
3/22/2003 10:20	4.62 hrs.	TQUEN	Quench at F17L, possible collimator problems.	x	T:QA42	1
3/22/2003 23:02	2.18 hrs.	TQUEN	quench while loading final protons; NXBNCH did not increment	x		46
3/25/2003 13:00	44 min.	TQUEN	Quench @ C11U at beginning of ramp	x		
3/29/2003 1:18	1.70 hrs.	TQUEN	Quench at E4 during pbar loading.	x		
4/1/2003 20:36	1.87 hrs.	TQUEN	Quench @E48u; chromaticity change during studies caused beam to go coherent	x		
4/3/2003 18:40	2.95 hrs.	TQUEN	quench - C11L, F48L; 2230 Amps, Store 2389 killed - investigating cause	x		
4/4/2003 3:21	55 min.	TQUEN	Quench F32U: approx 2230 amps, high losses after tuning	x		
4/8/2003 0:58	45 min.	TQUEN	A11L quench. TEL not set up right upno store termination	x		
4/8/2003 13:10	2.83 hrs.	TQUEN	BBU1 quench during abort of 36x4.	x		
4/8/2003 23:07	3.73 hrs.	TQUEN	Tev quench A11U, A13U, BAD3, BBU1, BBD2.	x		
4/11/2003 2:25	1.85 hrs.	TQUEN	Quench at D0 and C48U, C48L	x		
4/14/2003 13:45	2.83 hrs.	TQUEN	Quench F48L during abort caused by C:B0Q9 trip	x		
4/15/2003 16:34	1.18 hrs.	TQUEN	Low beta quench BA & BB; during studies.	x		
4/23/2003 7:44	1.43 hrs.	TQUEN	Tev quench low betas BA&BB	x		
4/25/2003 12:54	1.45 hrs.	TQUEN	Quench BAD3 & BBD1 during beam abort at Low Beta\	x		
4/26/2003 1:02	58 min.	TQUEN	Quench @A11U when C:BQ7 didn't ramp	x		
5/2/2003 19:44	2.27 hrs.	TQUEN	Quench during EOS studies at D48L	x		
5/7/2003 3:50	2.47 hrs.	TQUEN	F34U quench while tuning for shot setup.	x		
5/7/2003 8:59	1.02 hrs.	TQUEN	TeV quench at A48U.	x		
5/8/2003 23:56	1.57 hrs.	TQUEN	Quench DA, DB low betas; manipulating LBSEQ	x		
5/9/2003 22:26	4.68 hrs.	TQUEN	Tev quench at F3	x		
5/13/2003 23:18	4.78 hrs.	TQUEN	Quench at F17L during scraping of Store 2542 due to T:HE17 trip.	x		
5/14/2003 4:44	26 min.	TQUEN	F1, F2, & F3 quench during QBS test.	x		
5/14/2003 12:15	3.62 hrs.	TQUEN	B0 lowbeta quench	x		
5/15/2003 2:25	1.28 hrs.	TQUEN	T:QA42 trip causing an F48L quench.	x		
5/18/2003 20:50	4.33 hrs.	TQUEN	Tev Quench BA/BB low beat on beam abort	x		
5/19/2003 21:11	1.32 hrs.	TQUEN	Quench - F48L - investigating.	x		
5/21/2003 11:06	1.88 hrs.	TQUEN	Quench at F34U during Tev studies. Tev was at 150GeV.	x		
5/25/2003 18:34	50 min.	TQUEN	Tev quench E17U (150GeV)	x		
6/4/2003 18:28	3.82 hrs.	TQUEN	Quench at B46 lower.	x		

2/12/2003 13:28	18 min.	TPS	T:C0SH reference stuck, Tev ramping slowed.	D0QT2	2	
2/26/2003 5:50	1.03 hrs.	TPS	Injection aborts, high losses at F17 holding off studies.	C:BQ7	5	
2/27/2003 16:30	1.00 hrs.	TPS	Replaced Series Shunt Module in F3 PS dump cabinet;	C:BQ9	6	
3/1/2003 16:00	191.50 hrs.	TPS	Tevatron ground fault investigation/warmup/repairs	T:HE17	4	
3/10/2003 5:46	1.82 hrs.	TPS	Feeder 23 harmonic filter won't close.		17	47.22%
3/11/2003 18:49	2.10 hrs.	TPS	TEL modulator anode supply fan failure.			
3/12/2003 11:02	2.80 hrs.	TPS	Store lost due to B0Q5 trip. No quench.			
3/15/2003 19:48	8.00 hrs.	TPS	D0QT2 power supply tripped. PS chasis replaced.	X		
3/16/2003 19:45	4.03 hrs.	TPS	D0QT2 investigation and PS controller chassis replacement.	X		
4/14/2003 9:45	40 min.	TPS	T:QDE2 trip - fuse replaced			
4/14/2003 13:45	3.27 hrs.	TPS	C:B0Q9 trip on 'contactor interlock' fault - killed store 2426	X		
4/15/2003 10:35	1.32 hrs.	TPS	C:B0QT3 power supply problems.			
4/25/2003 1:10	1.58 hrs.	TPS	T:C0SH problems - Wall breaker popped			
4/25/2003 3:30	8.27 hrs.	TPS	BQ7 tripped while ramping - antiquench indication	X		
4/25/2003 8:00	6.48 hrs.	TPS	C:DQ0 trips when exiting the low beta squeeze (reversing switch problem)			
4/25/2003 16:15	2.83 hrs.	TPS	C:BQ7 tripped again; antiquench indication	X		
4/26/2003 1:02	2.58 hrs.	TPS	C:BQ7 didn't ramp, causing quench	X		
4/27/2003 12:11	5.73 hrs.	TPS	Store 2488 lost due to C:BQ7 trip.	X		
4/28/2003 11:17	3.38 hrs.	TPS	Store lost due to C:BQ9 & C:BQ7 trip.	X		
4/29/2003 14:27	3.50 hrs.	TPS	Store lost due to C:BQ9 trip. PLC input jumpered.	X		
5/6/2003 15:15	2.00 hrs.	TPS	C:BQ9 trip on control fault.	X		
5/6/2003 17:56	9.40 hrs.	TPS	C:AQ0, BQ0, CQ0 ramp problems.			
5/8/2003 9:31	43 min.	TPS	Added BQ9 diagnostics and checked B1 safety ground.	X		
5/8/2003 10:37	40 min.	TPS	T:HE17 tripped on quench indication.	X		
5/9/2003 4:56	27 min.	TPS	HE17 regulator changed out, was tripping on quench indication at LB.	X		
5/14/2003 3:35	5 min.	TPS	T:VC27 fuse fault.			
5/14/2003 4:05	30 min.	TPS	T:C0SH problems.			
5/15/2003 5:45	1.68 hrs.	TPS	D2 P.S. Door indication.			
5/15/2003 8:55	56 min.	TPS	QA42 regulator changed out. Bad connector found on original regulator.			
5/15/2003 9:47	7 min.	TPS	QB15 fuse fault indication. Regulator changed out.			
5/17/2003 9:08	3.80 hrs.	TPS	T:HE17 failure/trouble shooting	X		
5/21/2003 13:00	2.17 hrs.	TPS	T:HE17 problems and repairs.	X		
5/31/2003 17:50	1.25 hrs.	TPS	Lead failure at B0Q2,Q3 due to multiple leads too cold. Warming up w/ squeeze			
5/31/2003 19:30	40 min.	TPS	T:F17K2 fault.			
5/31/2003 20:30	1.33 hrs.	TPS	T:QFA4 is not outputting any current.			
6/4/2003 13:50	17 min.	TPS	C:B0Q2 readback problem.			

February to June

Quenches by Cause



The Bottom Line

- Maintenance and Infrastructure are expensive items. I have been handed a machine and supporting infrastructure that is reaching 35 years of age!
- It takes money.
- Infrastructure "bills" fall out of the sky. (HVAC in BTE/W \$640k notified 4-21-03)

Conclusion

- We take machine Reliability and Availability seriously.
- We are doing everything we can to keep the program running at the highest level of efficiency.
- We are attempting to set the proper priorities for some very expensive items.